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Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,399,472,** on September 6, 2002, by **KARINE LAPOINTE, CHRISTINE CANET and ROBERT ST-AMOUR,** for "Printing Media Evaluation Method".

Agent certificateur/Certifying Officer

August 3, 2005

Date

Canada

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OPIC CIPO

PRINTING MEDIA EVALUATION METHOD

BACKGROUND OF THE INVENTION

1. Field of the invention:

The present invention relates to methods for evaluating the quality of printing media such as inks or dyes. More particularly, the invention contemplates a method for comparing data from a whole printing ink sample to reference data and predicting impact on its quality, characteristics or performance in a printing process, in order to make a decision generally of the pass or fail type.

2. Brief description of the prior art:

Although ink supplies represent the second highest expense after substrates, for the production of printed products, little care and efforts have been devoted so far to control properties of ink supplies and their impact on production costs and quality. For instance, slight changes in an ink formula may result in a reduction of performance or efficiency, leading to substantial but hardly identified consumption and cost increases. For a large printing house, such variations in ink quality may result in millions of dollars of extra costs annually. Furthermore, introduction of improper ink in a printing process may require stop and cleaning of a press, which is highly troublesome and costly.

In order to reduce occurrence of the aforementioned drawbacks, some quality control is carried out on printed samples or on whole (unprinted wet state as supplied by manufacturers) ink samples. However, while evaluation of printed samples (generally by simple

photometric measurements) produces a late indication of a problem and mainly addresses visual quality problems, testing whole ink prior to printing is typically carried out in laboratory through an extensive series of physical and mechanical tests, such as strength of ink, opacity, viscosity, etc., requiring fair amounts of ink samples and time. Further, differences between the physical or mechanical properties of a sample with respect to reference values do not provide clear indication of the resulting impact on in-process performance of the tested ink.

For instance, US patent No 5,967,033, issued to Pfeiffer et al on October 19, 1999, discloses a method for determining ink coverage in a print image by analysis of an optical signal in the visible and near-infrared domain, reflected from a printed substrate. Similarly, in US patent No 4,935,628 (Martin et al. - June 19, 1990), ink from a writing instrument dried on a substrate is irradiated at multiple frequencies in the visible and infrared spectrum, and the reflected signal is analysed for differentiation and authentication purposes by comparison with spectra from a database. US patent 6,275,285 (Nottke et al. - August 14, 2001) also teaches a method for authentication of a dried ink sample on a substrate, but uses RAMAN spectrometry to obtain a higher level of resolution and discrimination of ink spectral signatures.

In US patent No 5,373,366, granted to Bowers on December 13, 1994, concentration of a liquid ink sample is measured through illumination of the sample with a Light Emitting Diode and analysis of the direct and reflected signal using photodiodes. In a like manner, publication No 60-202172A (Sato et al. - December 10, 1985), discloses an ink production unit wherein liquid ink samples are analysed by UV/Visible spectrophotometry to provide indication of the density and generate appropriate feedback on the

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production unit for adjustment of the dilution rate. In US patent No 6, 287,374 (Yanagida et al. - September 11, 2001), wetting properties of a pigment in a water base liquid ink are measured by infrared spectrometry. In Japan publication No 03-238345A, concentration of residual ink in paper pulp is measured by analysis of the signature of ink absorption in the near-infrared spectrum.

It is worth mentioning that most of the above mentioned technologies of the prior art concern jet-printing inks and writing instrument inks and that technologies used in connection with offset printing inks or the like are generally of the spectrophotometric type. Therefore, none of the existing techniques provide an appropriate means for evaluating properties and quality of a whole printing ink, and especially with regard to in-process performance. However, the prior art teaches that infrared (IR) and near-infrared (NIR) spectrometry enable extended characterization of an ink, providing some sort of distinctive signature (also referred to as fingerprint). Indeed, such techniques proved to be very effective for chemometric analysis of organic components such as resins, pigments or solvents found in media such as paints, dyes or inks, as well as for quality control in the pharmaceutical industry.

A few scientific publications confirm that FT-IR and FT-NIR spectra of a liquid ink solution provide a unique signature, usable for authentication purposes. For instance, Rena A. Merrill and Edward G. Bartick in "Analysis of Ballpoint Pen inks by Diffuse Reflectance Infrared Spectrometry" (Journal of Forensic Sciences, JFSCA, Vol 37, No 2, March 1992, pp 528 - 541) stated that Diffuse Reflectance (DR) Fourier Transform Infrared Spectrometry (FT-IR) provides good results in matching spectra from ink solutions extracted from a questioned

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document with spectra from pure whole ink samples from a data base for identification purposes. The major causes of errors are related to the presence of substrate traces in the extracted ink solution.

Although the above examples show that different existing methods contemplate detection or evaluation of ink properties, no method of the prior art is readily applicable to evaluation of a whole printing ink to enable reliable prediction of functional characteristics thereof and identification of any aspect that may negatively affect performance of the ink in a printing process such as offset, gravure, flexography, etc.

There is thus a need for a novel method overcoming the limitations and drawbacks of the methods of the prior art, which can be carried out using a very small whole printing ink sample from an ink supply, to provide indication of the degree of compliance with reference ink data to enable a pass or fail decision and/or predict in-process performance characteristics prior to introduction into the actual process.

SUMMARY OF THE INVENTION

More specifically, in accordance with the invention as broadly claimed, there is provided a method for evaluating a whole printing medium destined to introduction into a printing process, the method comprising the steps of:

1. obtaining FT-IR and/or FT-NIR spectral data of a sample drawn from a supply of whole printing medium;
2. performing analysis using spectral data from step 1 according to at least one predetermined criteria; and,
3. making a decision about the printing medium based at least partly on an outcome of step 2.

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According to further embodiments of the present invention:

The whole printing medium comprises a printing ink in manufacturer supplied state.

The printing process comprises offset lithographic printing.

The printing process comprises flexographic printing.

The printing process comprises gravure or intaglio printing.

The printing process comprises (silk) screen printing.

Step 1 comprises obtaining both FT-IR and FT-NIR spectral data.

Step 1 comprises obtaining FT-IR and FT-NIR spectral data of the printing media sample through an air tight enclosure in which it is placed to include volatile components thereof.

Step 1 comprises obtaining FT-IR and/or FT-NIR spectral data by diffuse reflectance.

Step 1 comprises obtaining FT-IR and/or FT-NIR spectral data by transmission.

Step 2 further comprises comparing data obtained at step 1 with reference FT-IR and/or FT-NIR spectral data.

In step 2, reference FT-IR and/or FT-NIR spectral data comprises data obtained from printing media complying with a desired level of performance.

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Step 2 further comprises determining if a sample spectral data set conforms to a reference spectral data set according to predetermined tolerance criteria.

In step 2, reference FT-IR and/or FT-NIR spectral data comprises data obtained from printing media presenting quality problems and/or causing problems of performance when introduced into the printing process.

Step 2 further comprises determining a best fit between a sample spectral data set and a plurality of spectral data sets stored into a database (library), representing a training set for a given characteristic or performance parameter of the printing ink.

Step 2 comprises determining a level of predicted compliance of the printing medium with a desired level of quality or performance in the printing process.

Step 2 comprises predicting and identifying specific problems of quality or of performance should the printing medium be introduced into the printing process.

Step 2 comprises characterizing at least one functional parameter of the printing medium. (ex. coverage, mileage ...).

Step 2 comprises characterizing at least one chemical parameter of the printing medium. (ex. Resin, solvant, pigment ...).

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Step 2 comprises characterizing at least one physical parameter of the printing medium. (ex. Tack, density, strength, viscosity...)

Step 2 further comprises performing parametric analysis of a sample spectral data set, through the application of operations on parameters characterizing at least one predetermined portion of said data set, and, more particularly, performing multi-variable parametric analysis of a plurality of portions of said data set.

Step 3 comprises deciding whether the supply of printing medium meets a predetermined quality standard.

Step 3 comprises deciding whether or not the printing medium should be introduced into the printing process.

Step 3 comprises deciding whether or not the supply of whole printing medium should be subjected to further testing.

There is further disclosed a method for evaluating whole printing inks, comprising the steps of:

1. Receiving a colour printing ink sample from a supply,
2. Carrying out Infrared spectral analysis of the sample,
3. Accepting the ink supply if the outcome of step 2 is within tolerance.

In a further embodiment of the method for evaluating whole printing inks, step 3 further comprises carrying out a standard testing procedure on more samples from the supply, should the outcome of step 2 be out of tolerance, and the method further comprises step 4: Accepting an out of tolerance ink supply succeeding at the standard testing

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procedure, and rejecting an out of tolerance ink supply failing at the standard testing procedure.

As will become more apparent from reading of the following detailed description, the present invention overcomes the limitations and drawbacks of the above mentioned solutions of the prior art, and amongst other advantageous features the following can be enlighten:

- The present invention provides a printing media evaluation method that can be applied to a wide range of whole printing inks in the manufacturer supplied state.

- The present invention provides a printing media evaluation method that can be performed rapidly and economically with a very small volume of media in an industrial plant.

- The present invention provides a printing media evaluation method that can carried out offline, without requiring introduction of the evaluated medium into a printing process and generally without requiring mechanical or physical testing.

- The present invention provides a printing media evaluation method enabling acceptance or rejection of a printing ink supply according to the degree of compliance with a reference master ink (identification).

- The present invention further provides a printing media evaluation method that can provide indication of the performance of a printing ink in a printing process.

- The present invention provides a printing media evaluation method that can provide advanced indication of

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quality or performance problems associated with of a printing ink.

- The present invention provides a printing media evaluation method that can provide quantitative characterization of functional, chemical or physical parameters associated with a printing ink, by comparison with a training set or by direct parametric analysis.

- The present invention still further provides a printing media evaluation method that can generate substantial cost savings in printing houses by ensuring ongoing compliance of ink supplies with reference quality standards.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a schematic representation of a typical set-up for obtaining FT-IR spectral data from a whole printing medium sample, according to the method of the present invention.

Figure 2 is a representation of a typical FT-MIR (mid-infrared) spectral pattern (spectrum) obtained from and representing the signature of a reference whole printing ink sample.

Figure 3 represents a similar view to Figure 2, representing a FT-IR spectral pattern obtained from and representing the signature of a first batch whole printing ink sample of the same formula as the sample of Figure 2.

Figure 4 is a representation of a FT-IR spectral pattern obtained from and representing the

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signature of a second batch whole printing ink sample of the same formula as the sample of Figure 2.

Figure 5a shows a graphic representation of the arithmetic difference, indicative of deviations between the spectrums of Figures 3 and 2.

Figure 5b shows a graphic representation of the arithmetic difference, indicative of deviations between the spectrums of Figures 4 and 2.

Figure 6 represents a flow chart of an extensive printing media evaluation method, according to the present invention.

Similar reference numerals refer to similar parts throughout the various Figures.

DETAILED DESCRIPTION OF THE INVENTION

Preferred embodiments of the printing media evaluation method according to the present invention will now be described in detail referring to the appended drawings.

The printing media evaluation method of the present invention basically consists in obtaining reflective or transmission spectral data representing a signature of whole printing ink samples and comparing and/or analyzing data sets in order to make a decision about a sample being evaluated.

Complete, accurate, repeatable and distinctive signatures are preferably obtained by submitting samples to Fourier Transform Infrared (FT-IR) interferometric analysis

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according to a test set-up of the type illustrated at Figure 1, representing a typical interferometer system. A sample **10**, consisting in a drop or small quantity of ink drawn from a supply of whole printing ink, is irradiated by a light source **12** in a specific spectral range of the infrared spectrum. Alternatively, a light source of different spectral range may be used to carry out analysis in the near infrared (NIR) spectrum, providing different and complementary signature data. Energy from the radiation source **12** is selectively absorbed by chemical elements of the ink sample **10** and a unique reflected or transmitted time distributed scattered radiation response for a given formula is collected by optics **11** and directed toward an infrared detector **13**. The analog response signal from detector **13** is digitized through an AD converter **14** and inputted into a computer **15** for a given period of time, and the time domain response is mathematically converted to a frequency domain format by Fourier transformation, providing a spectral data set that can be represented under an energy/frequency (wavenumber) pattern (absorbance spectrum **16**) as shown with more details on Figure 2. Spectral data sets representative of different whole ink samples are stored in a database (library) in computer **15** and can be transferred into an other computer.

Different ways of mounting the whole ink sample into the interferometer can be contemplated. Directing source radiation on the sample with an angle and collecting the reflected scattered radiation will provide a spectrum that is rather representative of the chemical elements at the surface of the sample. Alternatively, radiation transmitted through the sample can be collected, providing a spectrum better representing the whole ink formula. Preferably, transmission measurements can be carried-out with the ink sample enclosed in a gas tight enclosure, to better prevent evaporation of volatile components so to

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provide the maximum information possible and in turn, maximal discrimination between two similar samples.

A proprietary custom software implemented in computer **15** or another computer serves to perform advanced comparisons and analysis using stored FT-IR or FT-NIR spectral data sets.

It is worth mentioning that elements such as **11**, **12** and **13** of testing apparatus (interferometer) may be located in a sort of probe, wand or gun, remotely from a base station and computer **15**, so to enable direct access to an ink supply or sample nearby a printing press in a printing plant. Thereby, ink supplies can be conveniently evaluated on site by merely dipping an extremity of the probe into an ink supply to access a portion thereof (sample) and provide nearly immediate results.

The method contemplates a first way of providing an evaluation of a whole printing ink from a given production batch, wherein an FT-IR data set from a sample thereof, such as represented in Figure 3, is compared with a FT-IR data set from a sample from a reference (master) batch of known properties, such as represented in Figure 2. It should be noted that the sample of Figure 2 and that of Figure 3 represent different production batches of the same ink product (cyan lithographic process ink) from the same manufacturer. In the illustrated example, the ink supply corresponding to Figure 3 has a coverage value (as measured through a standard analytical method), which is 24% lower than that of the reference ink supply corresponding to Figure 2.

Figure 5a schematically represents a comparison of the sets of data of Figure 2 and Figure 3 by arithmetic difference to emphasize deviations between respective

intensities of both sets of data. Accordingly, by applying previously defined tolerance criteria to deviations, matching of the reference properties by the evaluated ink supply can be determined, a pass or fail type of outcome can issued and appropriate decision can be made about the evaluated ink supply.

Definition of the tolerance criteria is the result of extensive experimentation whereby FT-IR and FT-NIR spectral data sets from numerous whole ink supplies of slightly different chemical composition were obtained, followed by physical and mechanical testing and introduction of the ink supply into a printing process. Physical, mechanical and functional properties of each ink supply were recorded and correlations with spectral data sets were established. Therefore, the impact on ink properties of deviations with respect to a reference accepted (master) batch can be predicted with a sufficient level of confidence to make a pass or fail decision.

Moreover, training sets can be constructed for each of a plurality of ink parameters, indicating variations in spectrums (such variations of peak amplitude, shape or position) corresponding to incremental variations in quantitative value of said parameter. Therefore, the know how developed through experimentation and incorporated into the proprietary analysis software enables some parametric analysis of a differential spectrum such as represented in Figures 5a and 5b or direct parametric analysis of a spectrum as represented in Figure 2. Portions of the differential or original spectral data set (bands) can be identified in which deviation in amplitude, shape shifting, etc. can be associated with properties of the ink supply and indicative of potential problems or compromised performance if introduced into a printing process. A training set can be used to quantify a parameter by finding

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the best fit between a sample's spectrum and those of the corresponding training set, or by an algorithm elaborated to directly predict the value (quantify) of a property of an ink sample by multivariable parametric analysis of its spectrum, based on the knowledge provided by a given training set.

For instance, referring to Figure 5a, one can easily notice very significant positive peaks **50** near the right end of the spectrum, around 1000 cm^{-1}. That general region is associated with chemical components mainly characteristic of the pigment and oil components of the ink. These components are also those associated with coverage that is function of pigment density and transfer properties (which depend on superficial tension etc.).

It has been proposed and validated that the presence of the positive peak in that region is associated with poor coverage characteristics. Conversely, as seen on Figure 5c, absence of the positive peaks and presence of negative peaks **51** in the same frequency band proved to be representative of coverage exceeding that of the reference ink of Figure 2. Actually, the ink supply that served to generate the spectrum of Figure 4 and the differential spectrum of Figure 5c has a measured coverage value 24% higher than that of the reference ink supply (Figure 2).

Therefore, identification of significant positive absorbance peaks between 1000 and 1100 cm^{-1} in the differential spectrum of a tested sample can be considered as an indication of poor anticipated coverage and lead to a fail status and rejection decision.

At a further level of analysis, data sets obtained through experimentation are stored into a database along with indications about properties of their respective

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corresponding ink samples. Analysis performed by the software can determine a best fit between the spectral data set from an evaluated sample and any data set stored in the database. Accordingly, successful matching with a data set of the database within previously defined tolerance criteria can lead to predicting properties of the evaluated batch, and its behaviour and performance if introduced into a printing process. Appropriate decisions can then be made about the evaluated supply and the corresponding production batch.

Turning now to Figure 6, an extensive method for evaluating printing media will now be described. The method for evaluating whole printing inks, according to a further embodiment of the present invention, can be used by a printing house (printer) to decide whether a received ink supply from an unknown batch should be introduced into a printing process. The method comprises the steps of:

1. Receiving colour printing ink samples from supplies,
2. Carrying out Fourier transform Infrared spectral analysis of samples,
3. Accepting an ink supply if the outcome of step 2 for the corresponding sample is within tolerances, else carrying out a standard testing procedure on more samples from the supply being out of tolerances,
4. Accepting an out of tolerance ink supply succeeding at the standard testing procedure, and rejecting an out of tolerance ink supply failing at the standard testing procedure.

One can easily appreciate that the above-described embodiments of the present invention provide effective and practical solutions for the evaluation of a broad range of whole printing inks with unmatched

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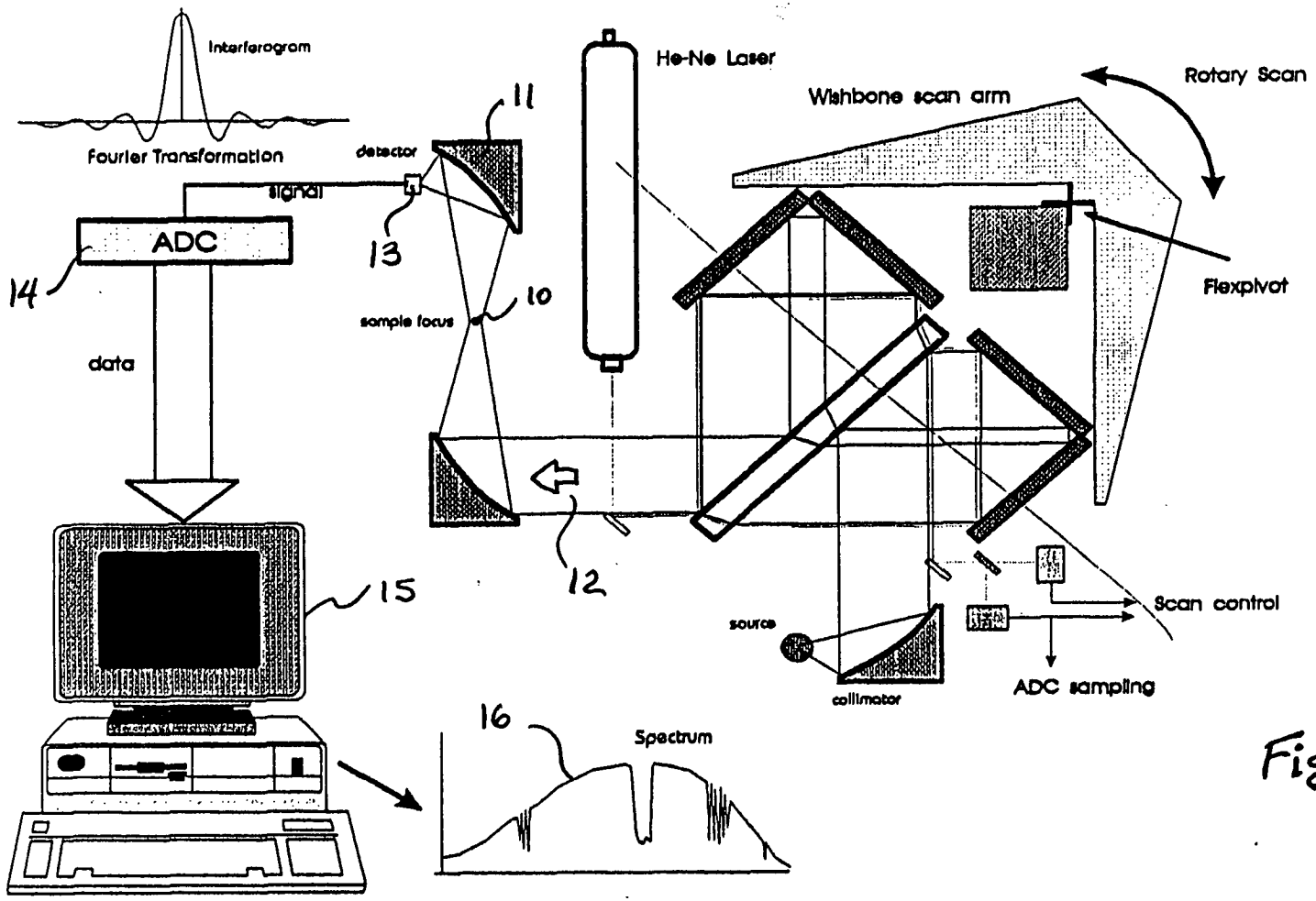
functional and economic performance with respect to solutions of the prior art.

Therefore, it can be seen that the printing media evaluation method according to the present invention can be advantageously used for ongoing control of the quality of ink supplies and of their performance in printing processes, thus providing printing houses (printers) with better control over their ink supply expenses and enabling substantial cost reduction.

Although the present invention has been described by means of a preferred embodiment thereof, it is contemplated that various modifications may be made thereto without departing from the spirit and scope of the present invention. Accordingly, it is intended that the embodiment described be considered only as illustrative of the present invention and that the scope thereof should not be limited thereto but be determined by reference to the claims hereinafter provided and their equivalents.

Inventors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13
11
He-Ne Laser
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sample focus
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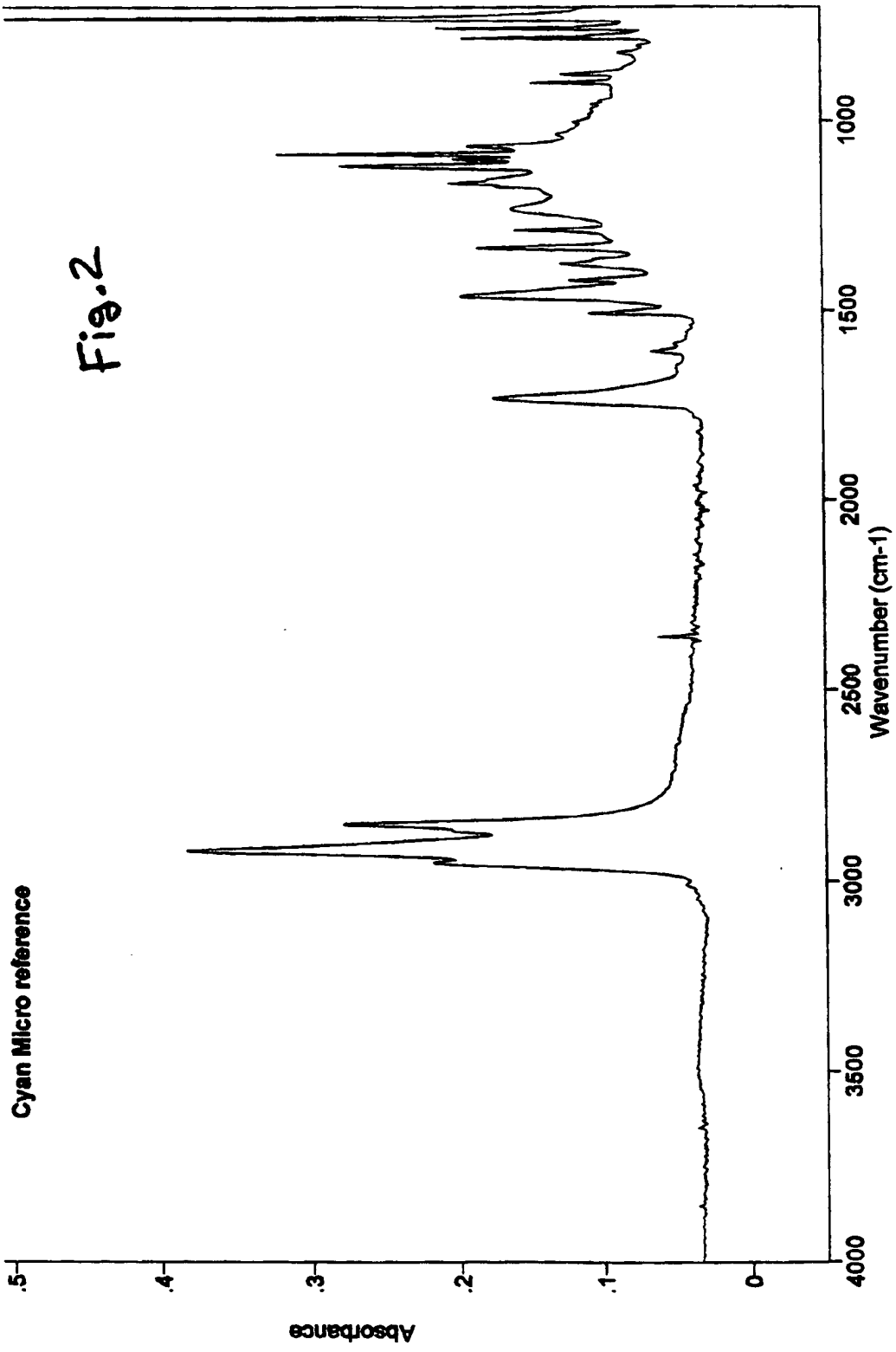
data
12
15
source
collimator
Scan control
ADC sampling
16
Spectrum

Fig. 1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3500
3000
2500
2000
1500
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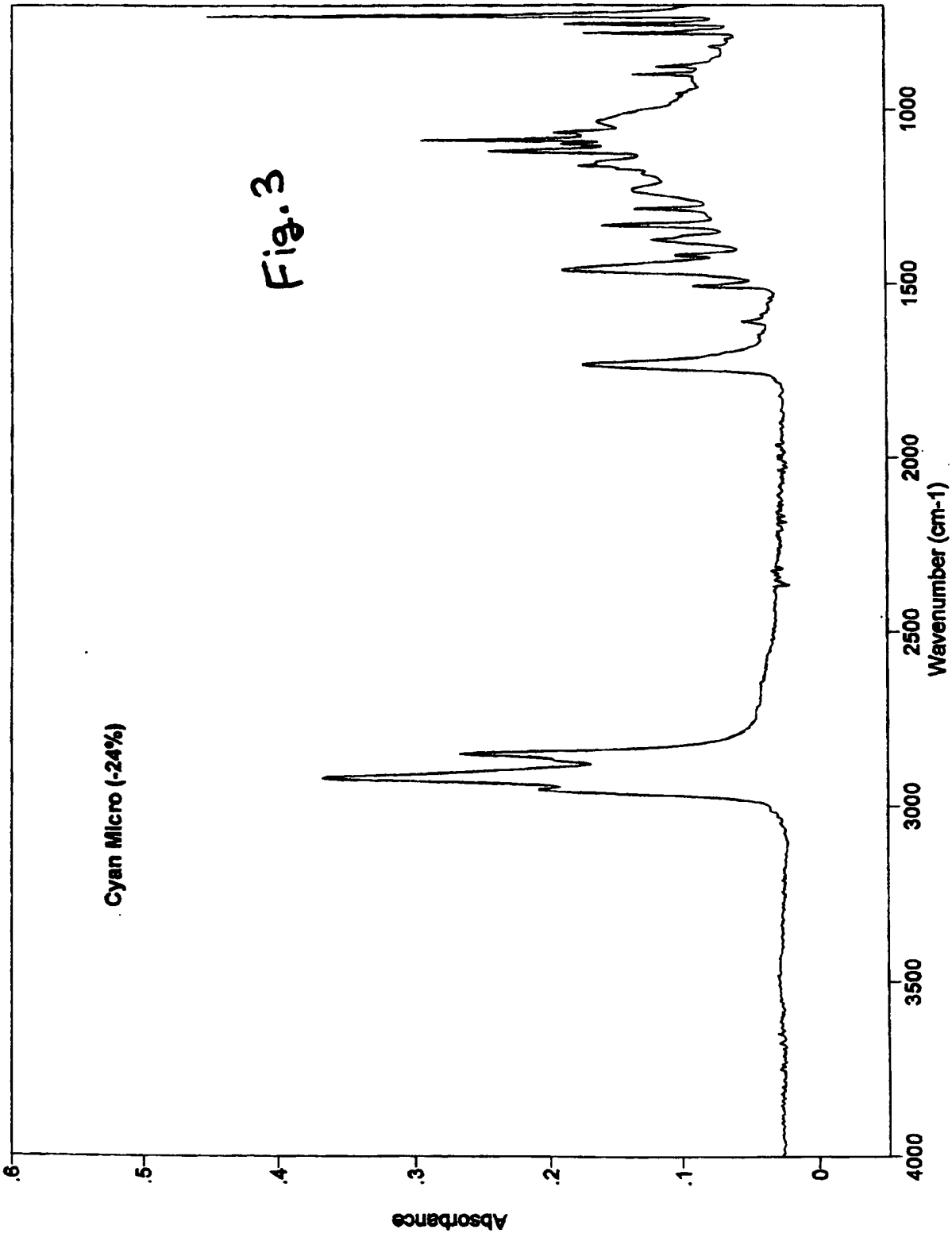
Wavenumber (cm-1)

Fig.2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4000
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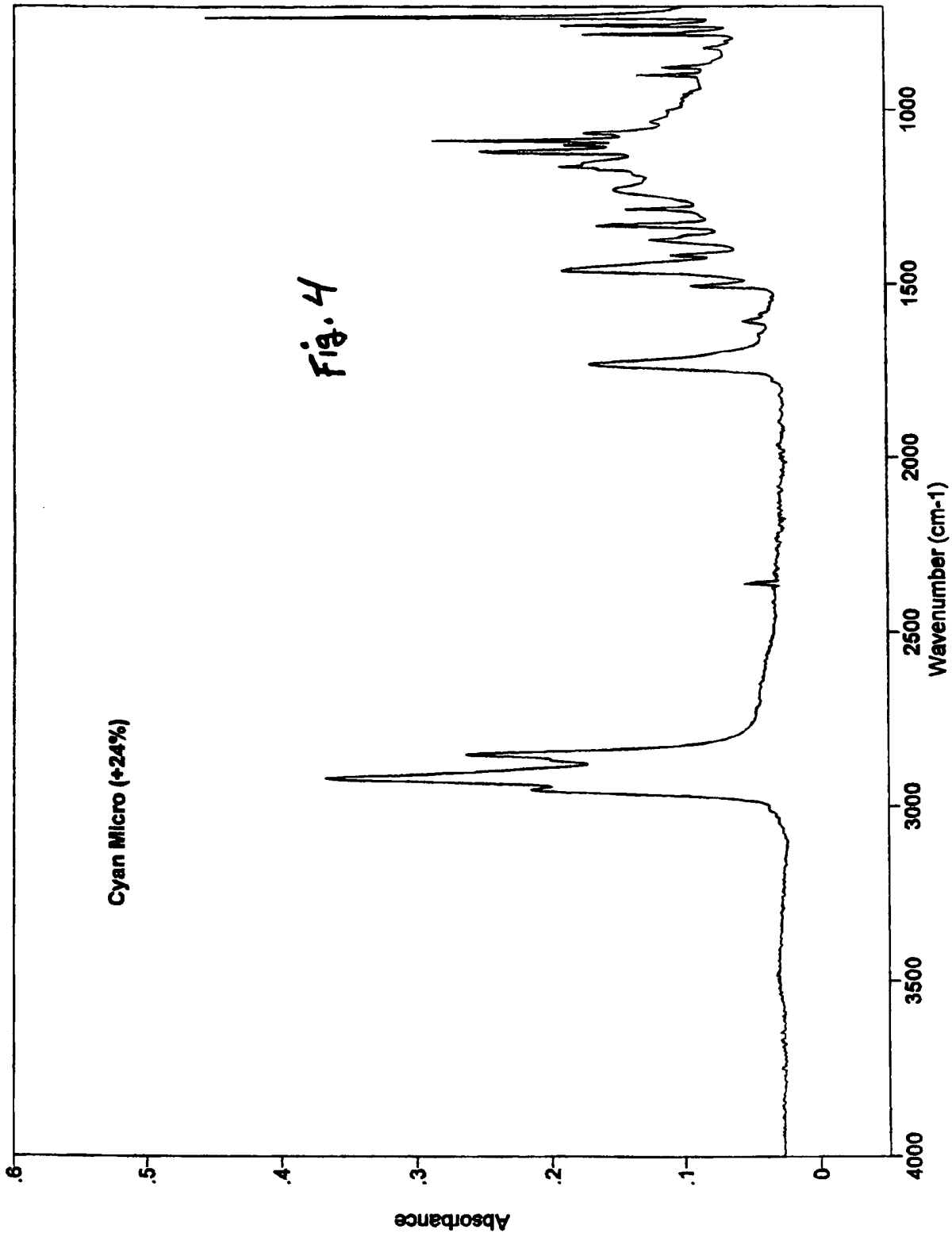
1000
Wavenumber (cm-1)

Fig. 3


Cyan Micro (+24%)
Absorbance
.6
.5
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.2
.1
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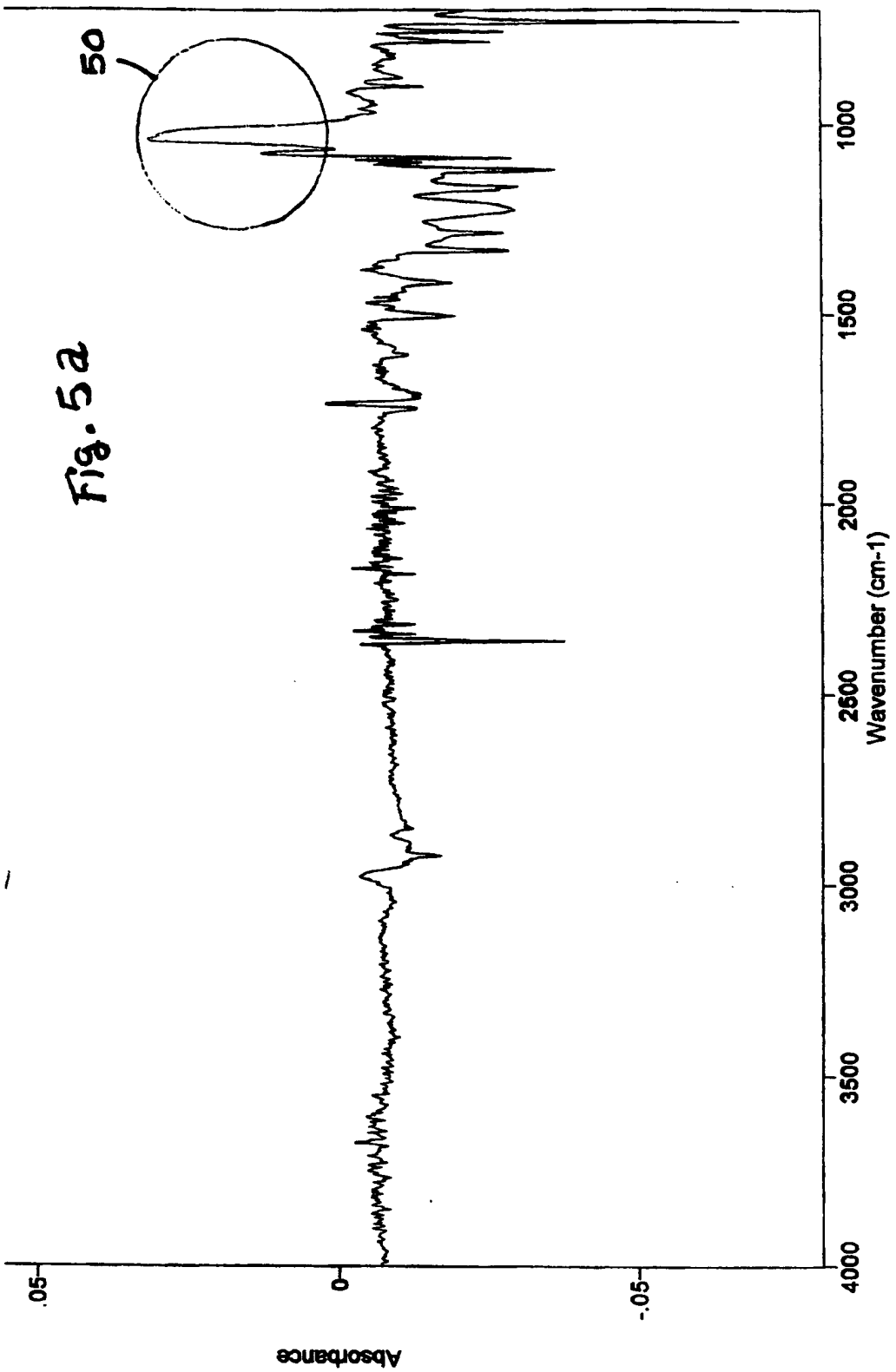
3500
3000
2500
2000
1500
1000
Wavenumber (cm-1)

Fig. 4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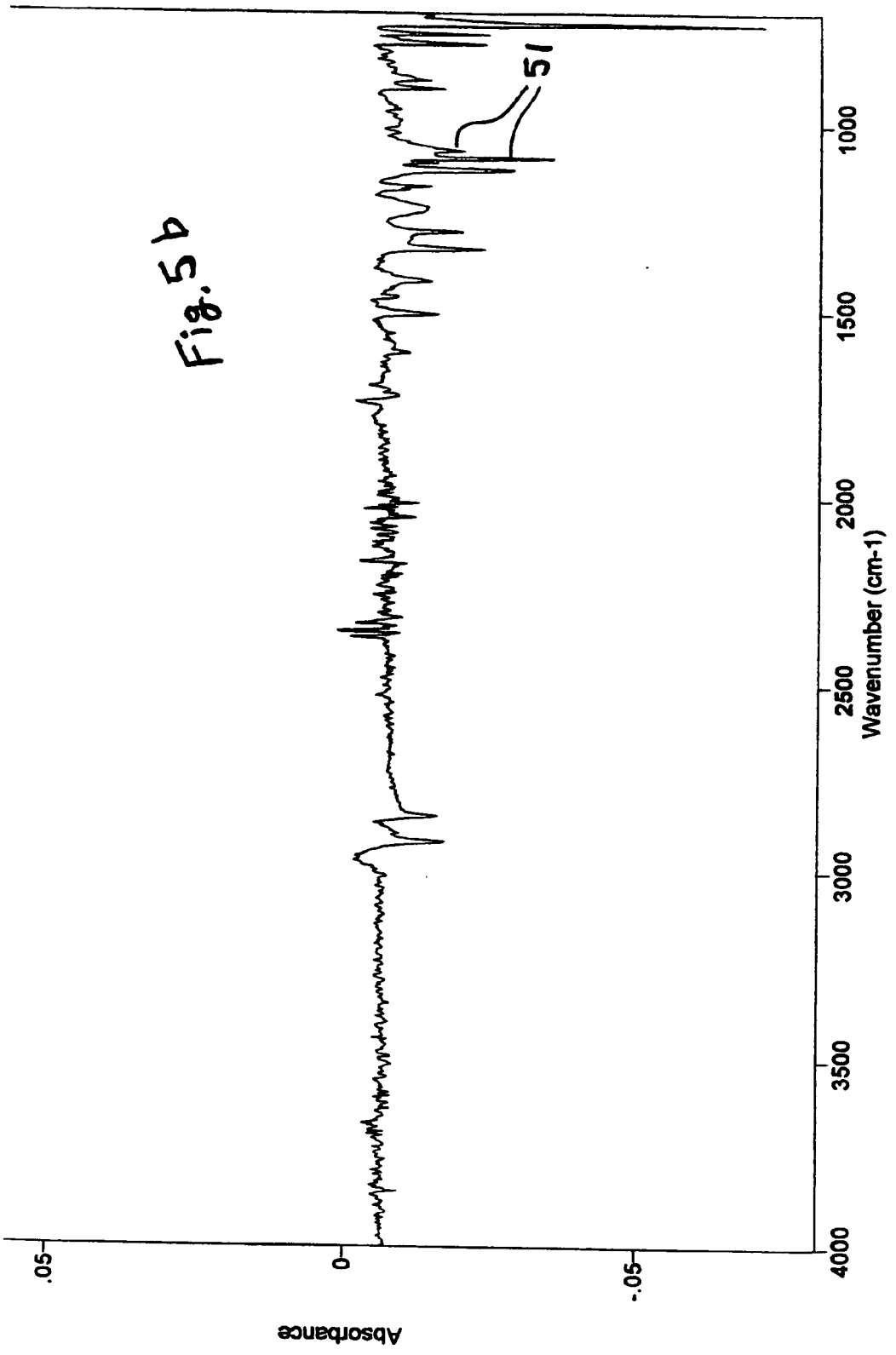
3000
2500
2000
1500
1000
Wavenumber (cm-1)

Fig. 5a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1000
Wavenumber (cm-1)
51

Fig. 5b

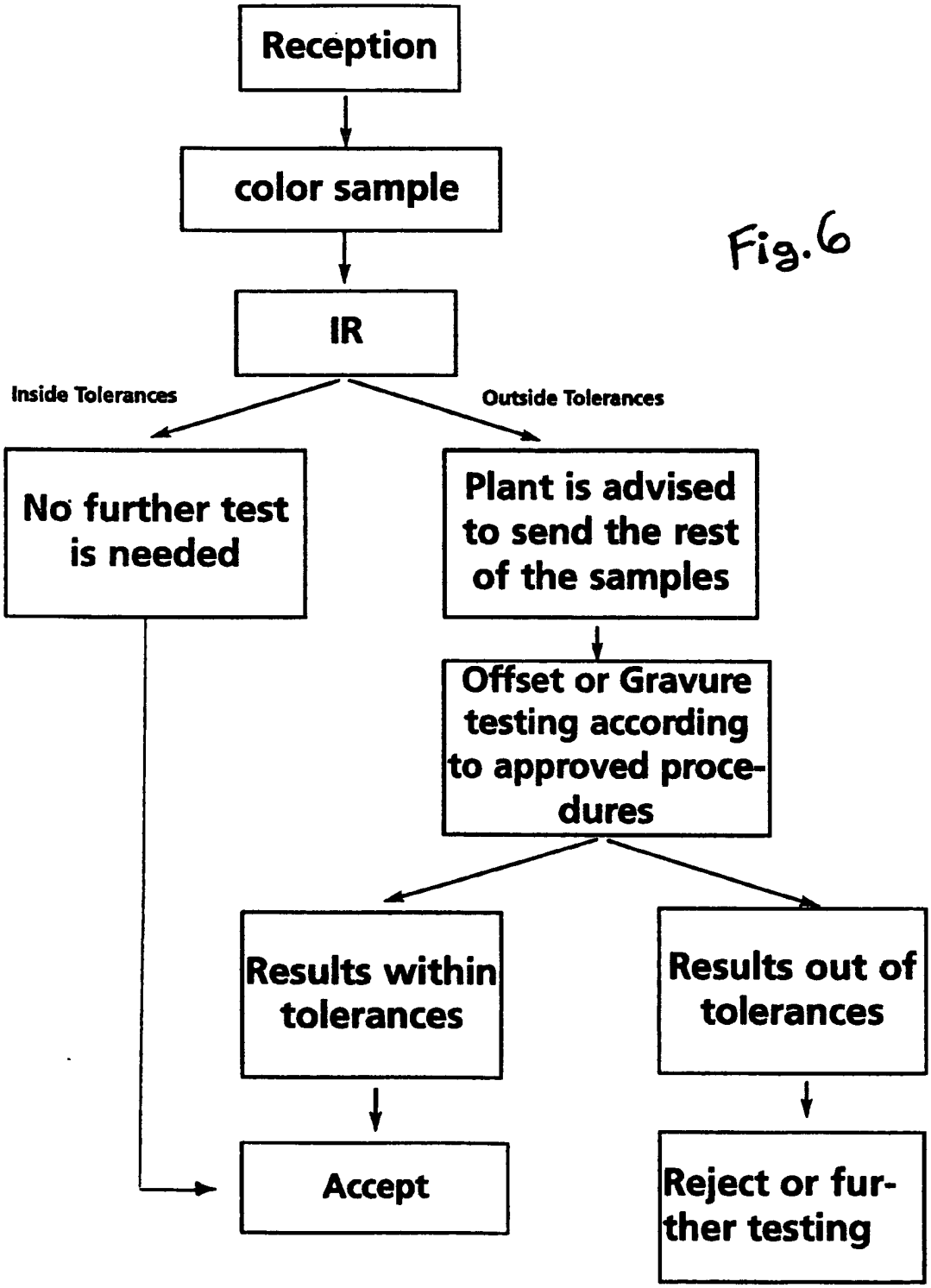
Reception
color sample
IR
Inside Tolerances
Outside Tolerances
No further test is needed
Plant is advised to send the rest of the samples
Offset or Gravure testing according to approved procedures
Results within tolerances
Results out of tolerances
Accept
Reject or further testing

Fig.6